CALORIMETER FOR THE MEASUREMENT OF SPECIFIC HEAT OF LAC

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ABSTRACT. For the measurement of the specific heat of lac and other bad conducting materials, a rectangular type of copper calorimeter is designed, which eliminates the sources of errors of the calorimeter used by Bhattacharya (1940). Specific heat of Kusum lac has been measured from room temperature to 110°C, at intervals of 5°C. The variation of its specific heat with temperature is discussed.

INTRODUCTION

Measurement of the specific heat of lac was undertaken to examine the behaviour of the variation of specific heat of lac at higher temperatures. The specific heat was measured from room temperature to 110°C, with a newly designed rectangular type of calorimeter. It is not desirable to extend this range beyond 110°C since the lac polymerises quickly after this temperature. Even in this short range several interesting features were revealed and it is hoped that a complete study may be useful for judging the quality and age of lac sample.

EXPERIMENTAL

The measurement of the specific heat of lac was made by Sen (1938-39) and Bhattacharya (1940) from 10°C to 40°C. The apparatus used by them consists of two hollow cylinders of same the length l and radii R and $2R$. Heating wire is wound round the inner cylinder and the thermometer is placed on the common axis for recording the temperature. The whole calorimeter is filled with lac. In such an arrangement following defects were felt.

1. The volume of lac contained inside the inner cylinder is $\pi R^2 l$, and that contained in the interspace of the cylinders is $\pi(2R)^2 l - \pi R^2 l = 3\pi R^2 l$. That is, on one side of the heater the material is three times that on the other side of it, and therefore the average temperature of lac in the two compartments cannot be expected to remain the same.

2. The thermometer is placed on the axis of the cylinders ; hence it will not record the average temperature of lac of the inner cylinder.

3. Lac is a bad conductor of heat, and no attempt seems to have been made towards the attainment of uniform temperature in the mass of the substance.

Considering these defects the calorimeter finally adopted, (figure 1) consists of a hollow rectangular copper vessel, with the closed bottom. A flat heater divides the vessel in two rectangular chambers along its length. Thus there are

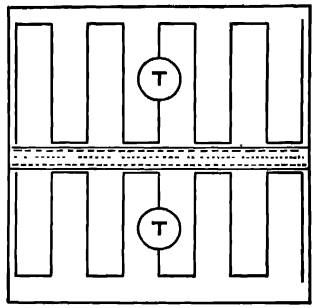

Fig. 1. Cross-sectional view of the calorimeter.

equal volumes of substance on the two sides of the heater in the two chambers, and the error due to the first objection is eliminated. Two thermometers, enclosed in copper covers, are placed such that their bulbs occupy the central positions in the two chambers. This rules out the second objection. Finally, two copper sheets are introduced in the zig-zag way in the two chambers to ensure the uniformity of temperature.

The dimensions of the actual calorimeter used were $1'' \times 1'' \times 4''$. Heating coil of approximately 30 ohms was wound flat on a thin insulator, and was finally covered by two thin insulating papers. Over these papers two copper sheets were placed, and the whole assembly was kept in the exact central position of the calorimeter, dividing it in two equal rectangular chambers. Four inches wide copper sheet was bent in the form of a rectangular wave with wavelength of $1/5''$ and amplitude of $3/16''$. It was placed in the calorimeter as shown in figure 1, in cross-section. Thus no part of the substance is farther than $1/20''$ from the highly conducting surface of copper sheet. Thus only in two minutes after the passage of current the temperature became constant.

The calorimeter was placed in a glass bottle, and the bottle was kept in a glycerine bath. The temperature of the bath could be increased by a heater and maintained constant by a thermo regulator and stirrer, and could be read by a thermometer. Current at nearly 16 volts was passed through the heater

of the calorimeter for about a minute and the rise in temperature was noted. Radiation correction was also applied. Water equivalent of empty calorimeter was determined in the routine way. Calorimeter was then filled with lac, and the specific heat computed after passing current and noting the rise in temperature, which was recorded by a thermometer which could read to 0 1°C. The rise is adjusted nearly 5°C for each determination, after which the temperature of the bath is kept constant for 15 minutes, and the thermometer is also seen to record the constant temperature for at least 10 minutes, before every fresh determination.

RESULTS

Specific heats of Kusum shellac of fresh and heat-hardened samples were measured and are tabulated in the Table I. Lac is polymerised after a few years of storage, and is rather useless for many purposes There are a number of prescribed tests to judge the quality of lac. However, the measurement of specific heat of a sample can enable us to estimate its age from the difference between its specific heat and that of the fresh sample at that temperature.

TABLE 1.

Temperature in °C	Specific heat of Lac Fresh	Heat hardened	Temperature in °C	Fresh	Specific heat of Lac Heat hardened
20–25	.33		65–70	.66	.53
25–30	.34	.30	70–75	.71	.53
30–35	.39	.32	75–80	.65	.53
35–40	.40	.34	80–85	58	
40–45	.45	.37	85–90	.57	
45–50	.54	.45	90–95	.57	
50–55	.57	.47	95–100	.57	
55–60	.64	.47	100–105	.57	
60–65	.62	.53	105–110	.56	

It may be noted that the specific heat varies very slowly in the range 20°C to 40°C, rising gradually from 0.33 to 0.40, while after this temperature it rises very rapidly, attaining a maximum value of 0.71 at 75°C. After 75°C it falls abruptly to a value of 0.58 at 85°C, and remains more or less constant upto 110°C, which is the maximum of the range. Bhattacharya (1940) has attributed the rapid rise to a continuousrate of fusion. Such a variation of specific heat for lac is due to its being a complicated mixture of various complex

organic substances of which little is known. However, lac has been separated in three portions hard and soft resins, and the lac wax, by physical means. These three fractions themselves contain innumerable complex organic substances. Thus from the variation of the specific heat it appears that as the temperature is raised, more and more constituents of lac begin melting resulting in an abnormal rise in the specific heat of lac. The maximum value of specific heat at 75°C and the abrupt fall in its value after this temperature indicate that maximum fraction of lac melts at 75°C, and the constancy in specific heat after this indicates that no more of the lac melts till the maximum range of measurement. Hence 75°C is taken to be the melting point of lac.

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